Evaluating projection methodology for Northwest Atlantic groundfish with consideration of biological assumptions and environmental influence

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Summary Population projections for several groundfish species in the Northwest Atlantic Ocean were evaluated for accuracy, and sources of bias were determined. Forecasts were made 'retrospectively,' i.e., assessment data were truncated and forecasts were made during a period with observed catches, observed biological factors (size, weight, maturity), and observed environmental conditions. Both the assessment model and the forecast model were age structured. This framework allowed evaluation of different forecast techniques, and the accuracy of different assumptions about biological factors and environmental interaction could be compared. A secondary consideration was the identification of a feasible time horizon for projections (how many years before forecasts become unreliable) and the implications this has for defining appropriate reference points.

Introduction For the last decade, some assessments of NWA groundfish have exhibited mild to severe retrospective bias, wherein running the model with additional years of data leads to the updated model estimates being consistently smaller (or consistently larger) than the earlier model estimates. This situation is problematic for providing catch advice, because quotas can be set that appear to meet rebuilding requirements and to avoid overfishing, yet when the assessment is updated the new estimates suggest that those quotas may have been set too high. Depending on the status of the stock, future quotas might need to be drastically smaller in order to correct for the previous quotas that were unintentionally set too high. This situation degrades confidence that stakeholders have in assessment results and reduces the ability of managers to adequately manage risk.

Materials and Methods NWA groundfish that are assessed using Virtual Population Analysis (VPA) were selected for this research. Retrospective models, with 1-7 years of data removed from the end of the full assessment time series, were created. The VPA methodology was then applied to the retrospective models. Each retrospective model was then forecast to the end of the original VPA time period so that retrospective model projections could be compared to the original VPA trajectory (Fig. 1). The assumptions made in the projections about future recruitment, biological parameters, and fishery selectivity, were tested one at a time by replacing assumed values with observed values to determine how sensitive results were to misspecification of these elements.

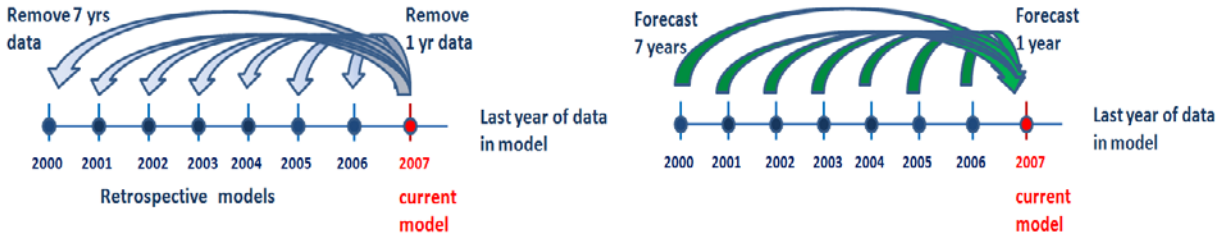

Figure 1. Diagram of the retrospective model generation from the full assessment model (left) and the projection models that forecast to the final year in the full assessment model.

Results and Discussion Overall, the single most important factor in determining the accuracy of projections was the bias in VPA estimated numbers at age in the terminal year +1 ("retrospective bias"). When starting from biased initial conditions, that bias propagated through the entire forecast horizon, with the amount of bias increasing with the length of the forecast (Fig. 2). In this case, bias in

stock projections could be reduced by accounting for this trend.For one stock, there was little retrospective bias, but very strong density effects on growth. Management advice for some of the stocks where the retrospective bias is severe is based on projections that adjust for past observed patterns of bias. This approach was tested for all stocks, regardless of the degree of bias.

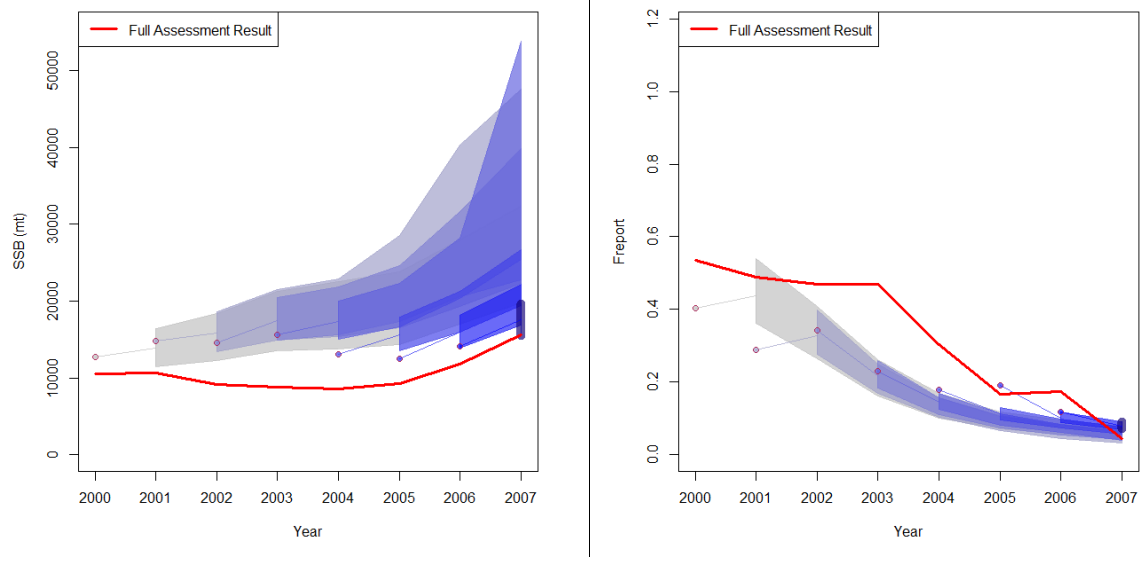

Figure 2. Example of forecasted 90% polygons from each retrospective model, illustrating positive retrospective bias in SSB (left) and negative retrospective bias in F (right).

The take home message from this investigation is that sources of bias in initial conditions need to be evaluated and reduced prior to projections, otherwise that bias is likely to propagate. Similarly, trends in biological parameters need to be considered. The assumptions made during the projection horizon can be evaluated by projecting from retrospective models, and it is recommended that such evaluations be conducted periodically to determine if the projection approach is performing as expected. Although this research focused on VPA assessments, retrospective bias is an issue that afflicts other types of assessment models, including statistical catch-at-age models. We therefore recommend that evaluation of retrospective bias be a standard diagnostic tool when conducting stock assessments.